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APPENDIX

BIS = Bureau of Indian Standards

BC = Bituminous Concrete

BBD = Benkelman Beam Deflection

BBMP = Bruhat Bangalore Mahanagara Palike BWSSB = Bangalore Water & Sewerage Supply Board BOQ = Bill of Quantities

CBR = California Bearing Ratio

CH = Chainage

DBM = Dense Bituminous Macadam

DTM = Digital Terrain Model

GSB = Granular Sub Base

HIP = Horizontal Intersection Points

IRC = Indian Road Congress

KM = Kilometer

MSA = Multi Scale Axle

MORT & H = Ministry Of Road Transport & Highway O/H = Over Head

OFC = Optical Fiber Cables

PCU = Passenger Car Unit

PWD = Public Work Department

PI = Plasticity Index
PMC = Project Management Consultant

RCC = Reinforced Cement Concrete

ROW = Right of Way

TBM = Temporary Bench Marks
WMM = Wet Mix Macadam

1. INTRODUCTION

Bangalore, the administrative, cultural, commercial and industrial centre of Karnataka, is rated as one of the world's fastest growing cities. It is the seventh largest city in India. It is also known as the Garden city because of its many beautiful gardens and parks. Though the origin of Bangalore is ancient, the present-day city was founded in the 16th Century and has since continued to be an important administrative center.

Bangalore is also the nerve center of India's software industry, thus attracting people from all over the country and beyond for seminars, conferences and exhibitions. Bangalore is a major attraction for its connectivity and climatic conditions. Being well connected by rail, road and air, it is served by many international airlines and hence making it a gateway to the south. Hence development of infrastructures is a happening mantra of present Bangalore to gift Bangaloreans as well as outside visitors a posh, cosmopolitan Bangalore.

Along with the population the city has also seen great improvements to its roads, highways and other infrastructure. Several flyovers have come into existences in the last years easing the traffic and making travel easier. Apart from this the stakeholders are also concerned about the services and aesthetics of streets and safety and comfort of the road user. The providing of road signage and other amenities on the footpath including installation and maintenance of street furniture in the city

During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolution changes that has taken place in the automobile industry. This has contributed to the growth of vehicular traffic in an enormous way.

In view of the above facts, road commuters are experiencing inconvenience and increased road user cost due to increase in the following factors.

- Intra city commuting time.
- Traffic congestions.
- Junction delays.
- And increased rate of accidents, health hazards etc.

Hence, there is an urgent necessity, to decongest these roads and intersection

To enhance services and aesthetics of streets, footpaths and open spaces and to provide comfort and convenience to the user, Bruhath Bangalore Mahanagagra Palike has proposed Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division. The Following Roads have been considered for improvements.

NEED OF THE PROJECT:

Bangalore city being cosmopolitan and Silicon Valley of India attracts lot of tourists. Improving the roads in the city enhances the civil amenities in the city.

With ever increasing growth in traffic and rapid urbanization, there is a continuous increase in congestion and population. Therefore there is need to bring out suitable measures to increase the basic amenities and infrastructure. The project would also have a positive impact and improve aesthetics and in turn would boost the overall image of the roads and the city as a whole.

The Proposed project roads are in bad condition without proper payment and drainage. The stretch mainly consists of many Residential establishments all along. To keep pace with the growth, it is techno economically feasible to take up this project along the mentioned stretches.

STUDIES & INVESTIGATIONS:

- **Object of the Study**

To identify the developmental improvements to be carried out on the existing basic amenities and infrastructure for the smooth functioning by itself, Therefore the improvement would include, providing geometrical improvements, drainage etc.

These have to be cost efficient while providing an easy maintenance. In short improvements, this shall be feasible technically, financially, socially, environmentally, and institutionally.

The end result of this objective will be a better living standard for the public in general and people around Yelahanka division in particularly.

- **Reconnaissance Survey**

The reconnaissance survey has been carried out to study the board aspects of the project. This includes identifying possible area/field/elements, which need improvements. The various studies, which have been carried out under this section area

- ❖ Possibility of Geometrical Improvement.
- ❖ Type and conditions of road
- ❖ Type and conditions of roadside drain, shoulder drain, Kerb & Gratings.

Detailed Road Inventory is given has been enclosed with this report

Culvert

RCC Walls with RCC cover has been provided at cross Roads

The proposed Road offers safe and efficient vehicular movement along the proposed Stretch

.

- Provide new Culvert with Cover

PROPOSALS:

Based on the detailed studies and investigations, proposals for the improvements to the above selected Roads is arrived and listed below

Road Pavement

For Earthen Roads Flexible Pavement with 150 mm Granular Sub-base, 200 mm Wet Mix Macadam 50 mm bituminous macadam & 40mm Bituminous Concrete has been provided.

1.1 Location

Table 1:-The Project Corridor under consideration details is as mentioned below

NEW CC DRAIN		
Description	**No/sides**	**Length(m)**
Anugraha Layout		
W1129 Ch:00-86 1st main road LHS	1	86.00
W1129 Ch:00-86 1st main road RHS balance	1	40.00
W0628 Ch:00-102 1st c/s road	2	102.00
W0636 Ch:00-184 3rd c/s road	2	184.00
Adithya Nagara 1st Stage		
W1173 Ch:00-910 High tention wire road from Yelahanka main road to Hesargatta road	2	900.00
W1363 Ch:00-86 2nd c/s	2	86.00
W1171 Ch:00-112 3rd c/s in High tention wire road	2	112.00
W0816 Ch:00-122 1st main Nikisa Hospital	1	60.00
W0804 Ch:00-88 N.D Traders road	2	88.00
W0800 Ch:00-190 High tention wire LHS Road	2	190.00
W1137 Ch:00-178 1st main road	2	178.00
W0632 Ch:00-86 2nd c/s road	2	86.00
W0638 Ch:00-45 3rd A c/s road	2	45.00
W0640 Ch:00-190 4th c/s road	2	190.00
W0786 Ch:00-50 4th A c/s road	2	50.00
Doddabettahalli		
W0929 Ch:00-92 6th main	2	92.00
W0500 Ch:00-112 Venkateshwara temple road	2	112.00
New Culvert		
New Culvert	25	6.70

The project road is located in Western Part of Bangalore City. Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division. The Project Corridor is located in residential and commercial area. The project area is developing on either side. Finally the total length proposed for improvement is 5196.00m New CC Drain, 25 new culverts 4351.00m New BC & 1246.00m New CC Road. The key plan of the project road is shown in below fig-1

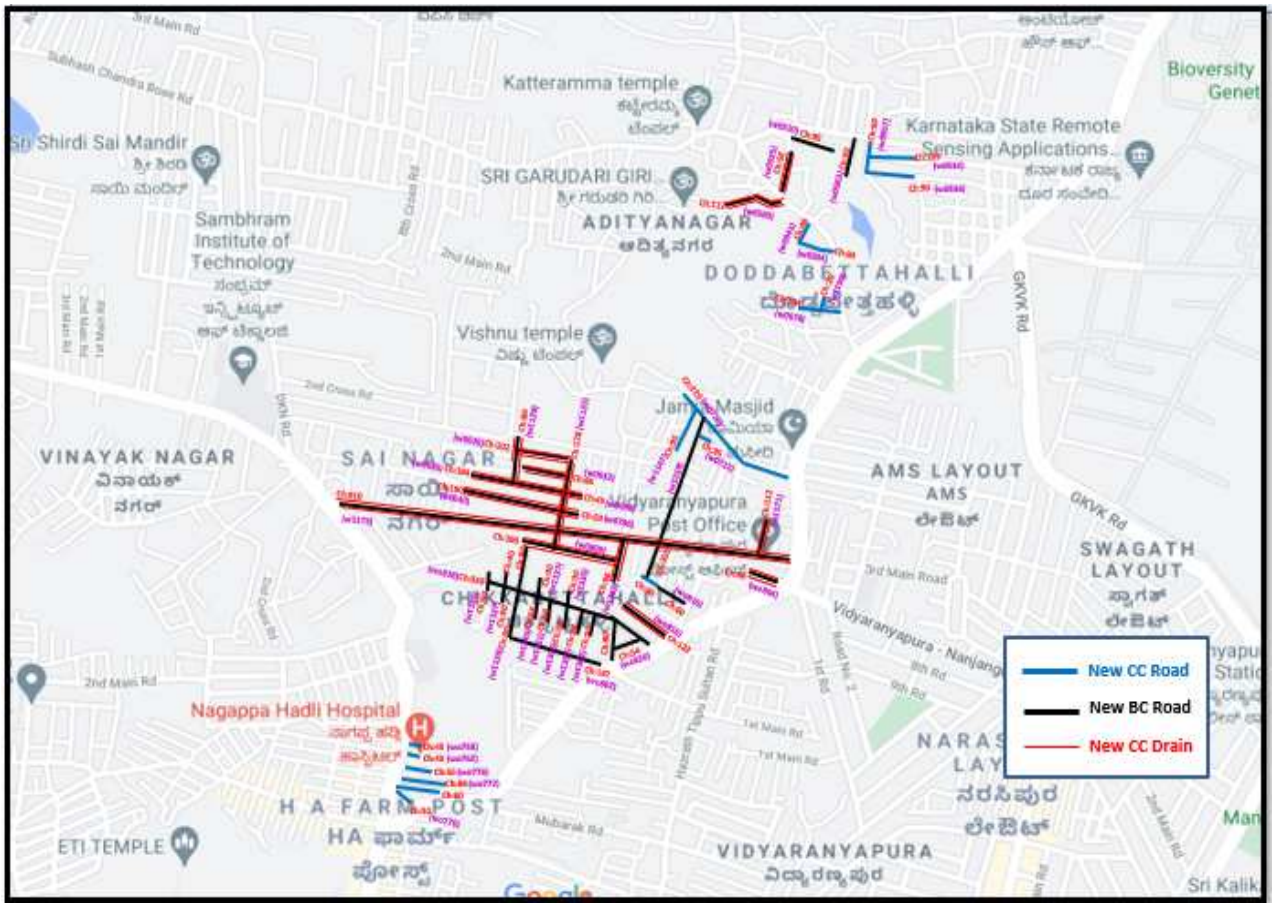

Figure 1:-Project Road

1.2 Project Background

Bruhat Bangalore Mahanagar Palike has decided to take up the development of various Arterial and Sub Arterial roads in and around Bangalore city **"Bangalore Smart city Grants"** where the intensity of traffic has increased significantly and there is a requirement for augmentation of capacity for safe and efficient movement of traffic.

SRI SAI CONSULTANT is entrusted by BBMP to carrying out the work of Preparation of Detailed Design Report for

1.3 Project Outline

The Project essentially consists of conducting Feasibility Studies including Preparation of Detailed Design report for Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division

1.4 Scope of Services

The scope of Services of the Consultancy includes the following:

I. Collect inventory data to do condition survey of road, bridge, culvert, as per IRC SP:19 and prepare inventory in the computerized format.
II. Conduct CBR test in case of formation of New Roads on the existing sub-grade as per IRC:37-2001.
III. Carry out Benkleman deflection beam test as per IRC: 81-1997 for over layer design in case of strengthening required.
IV. Prepare detailed Design Drawings.
V. To design Rehabilitation improvement repair measures of existing structures like road side drain, footpath, culverts etc.
VI. Detailed drawings shall be prepared to international standards using CAD. it will contains all details requirements for execution of project.
VII. Prepare Bill of Quantities and estimates based on current scheduled rate of PWD Bangalore Circle 2018-19

1.4.1. Engineering Surveys

Detailed Survey and investigations vise, reconnaissance's, condition of pavement, subgrade soil investigation, and inventory of structures have been carried out.

1.4.2. Road Inventory and condition survey of Bridges

A detailed Road Inventory and condition survey of Bridges has been carried out by making use of well-structured inventory data format.

1.4.3. Geotechnical investigation

Sampling of subgrade soil samples along the project road has been completed. The soil samples have been tested for relevant engineering properties and it has been used for detailed design of new bituminous pavement.

2. ROAD & PAVEMENT INVESTIGATIONS

2.1 Road Inventory Survey

A detailed road inventory survey was carried out to collect all data to a sufficient level of detail. It was compiled in tabular form, developed using Excel computer software. The data collected include.

a) Type terrain

b) Land use.

c) Carriageway width.

d) Type of surfacing.

e) Shoulder, Median, Drain (tertiary / shoulder), - type and width.

f) Road Geometry.

g) Road Furniture.

h) Illumination.

i) Salient Building & Structures.

j) Road Intersection(S) and their details.

k) Land width (ROW).

l) Culverts, bridges and other structures (type, size, span arrangement, and location).

m) General drainage condition

n) The detailed Road Inventory details are enclosed Annexure A.2.1.

2.2 Sub-Grade Characteristics And Strength

The data relating to soil classification and mechanical characteristic for soils along the existing alignment were collected.

Tests being performed on least three sub-grade soil samples for each homogenous road segment or three samples for each soil type encountered whichever is more.

The sub-grade soil being listed as follow:

- In-situ density and moisture content at each test pit.
- Characterization (grain size and Atterberg limits) at each test pit
- Laboratory moisture-density characteristics (modified AASHTO compaction).

2.3 Benkelman Beam Deflection

Benkelman Beam Deflection (BBD) test is not conducted as there is new construction for predominant length and overlay for small length. So just to improve riding quality of the road a uniform overlay thickness as that of new construction is considered.

2.4 Project Improvements

2.4.1Carriageway Improvements

Width of the carriageway on the entire stretch varies from 4.50m to 9.0m It is proposed to Development and strengthening of Road Surface.

2.4.2Geometric Improvements

Geometric design for a highway is direct by the land availability, requirements of traffic and economic consideration. The geometric design involves design of several elements such as horizontal alignment, vertical profile, sight distance considerations, cross section components, vertical clearance, intersection treatment, control of access, etc. The safety, efficiency, economy and comfort of vehicle operation are governed by the adequacy geometric standards used for a specific highway facility. For the purpose of formulating design standards, the Consultant has followed the design standards given in IRC codes and its special publications.

2.4.3 Pavement Design & Option

Field survey and investigation yielded the primary data on the current condition of the pavement. These data are necessary to accurately assess the adequacy of the pavement to withstand the present traffic loading to the future traffic demand. This study involves the following.

- Improvement of existing mud Road with new pavement crust
- Rehabilitation / Strengthening of existing pavement

3. CALIFORNIA BEARING RATIO (CBR)

3.1 Objects and Requirements of Pavements

The surface of the roadway should be stable and non-yielding, to allow the heavy wheel loads of road traffic to move with least possible rolling resistance. The road surface should also be even along the longitudinal profile to enable the fast vehicles to move safely and comfortably at the design speed. The earth road may not be able to fulfill any of the above requirements, especially during the varying conditions of traffic loads and the weather. At high moisture contents, the soil becomes weaker and soft and starts yielding under heavy wheel loads, thus increasing the tractive resistance. The unevenness and undulations of the surface along the longitudinal profile of the road causes vertical oscillations in the fast moving automobiles, increasing the fuel consumption and the wear of the vehicle components, resulting in a considerable increase in the vehicle operation cost. Apart from this uneven pavement surface causes discomfort and fatigue to the passengers of fast moving vehicles and cyclists. Therefore, in order to provide a stable and even surface for the traffic, the roadway is provided with a suitably designed and constructed pavement structure. Thus a pavement consisting of a few layers of pavement materials is constructed over a prepared soil subgrade to serve as a carriageway.

The pavement carries the wheel loads and transfer the load stresses through a wider area on the soil subgrade below. Thus the stresses transferred to the subgrade soil through the pavement layers are considerably lower than the contact pressure or compressive stresses under the wheel load on the pavement surface. The reduction in the wheel load stress due to the pavement depends both on its thickness and .the characteristics of the pavement layers. A pavement layer is considered more effective or superior, if it is able to distribute the wheel load stress through a larger area per unit depth of the layer. However, there will be a small amount of temporary deformation even on a good pavement surface when heavy wheel loads are applied. One of the objectives of a well designed and constructed pavement is therefore to keep this elastic deformation of the pavement within the permissible limits, so that the pavement can sustain a large number of repeated load applications during the design life

Based on the vertical alignment and the environmental conditions of the site, the pavement may be constructed over an embankment, cut or almost at the ground level itself. It is always

desirable to construct the pavement well above the maximum level <*l the ground water to keep the subgrade relatively dry even during monsoons.

3.2 Types of Pavement Structure

Based on the structural behavior, pavements are generally classified into two categories:

3.2.1 Flexible pavements

3.2.2 Rigid pavements

3.2.1. Flexible pavements

Flexible pavements are those, which have low or negligible flexural strength and are rather flexible in their structural action under the loads. The flexible pavement layers reflect the deformation of the lower layers on-to the surface of the layer. Thus if the lower layer of the pavement or soil subgrade is undulated, the flexible pavement surface also gets undulated. A typical flexible pavement consists of four components: (i) soil subgrade (ii) sub-base course (iii) base course and (iv) surface course.

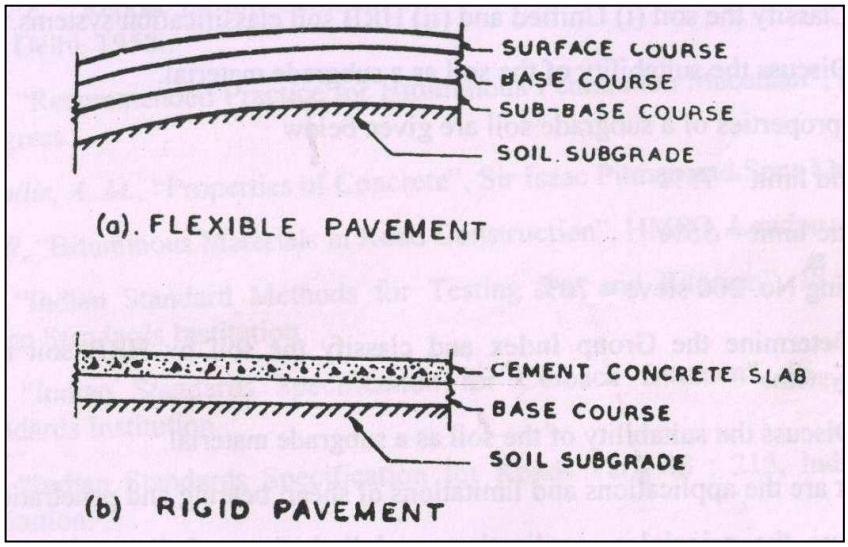

Figure 2:-Components of Flexible and Rigid Pavements

The flexible pavement layers transmit the vertical or compressive stresses to the lower layers by grain to grain transfer through type points of contact in the granular structure. A well compacted granular structure consisting of strong graded aggregate (interlocked aggregate structure with or without binder materials) can transfer the compressive stresses through a wider area and thus forms a good flexible pavement layer. The load spreading ability of this layer therefore depends on the type of the materials and the mix design factors. Bituminous concrete is one of the best flexible pavement layer materials. Other materials

which fall under the group are, all granular materials with or without bituminous binder, granular base and sub-base course materials like the Water Bound Macadam, crushed aggregate, gravel, soil-aggregate mixes etc.

The vertical compressive stress is Maximum on the pavement surface directly under the wheel load and is equal to the contact pressure under the wheel. Due to the ability to distribute the stresses to a larger area in the shape of **a** truncated cone, the stresses get decreased at the lower layers. Therefore by taking full advantage of the stress distribution characteristics of the flexible pavement, the **layer system concept** was developed. According to this, the flexible pavement may be constructed in a number of layers and the top layer has to be the strongest as the highest compressive stresses are to be sustained by this layer, in addition Jo the wear and tear due to the traffic. The lower layers have to take up only lesser magnitudes of stresses and there is no direct wearing action due to traffic loads, therefore inferior materials with lower cost can be used in the lower layers. The lowest layer is the prepared surface consisting of the local soil itself, called the subgrade. A typical cross section of a flexible pavement structure this consists of a wearing surface at the top, below which is the base course followed by the sub-base course and the lowest layer consists of the soil subgrade which has the lowest stability among the four typical flexible pavement components. Each of the flexible pavement layers above the subgrade, viz. sub-base, base course and the surface course may consist of one or more number of layers of the same or slightly different materials and specifications the vertical compressive stress is Maximum on the pavement surface directly under the wheel load and is equal to the contact pressure under the wheel. Due to the ability to distribute the stresses to a larger area in the shape of **a** truncated cone, the stresses get decreased at the lower layers. Therefore by taking full advantage of the stress distribution characteristics of the flexible pavement, the **layer system concept** was developed. According to this, the flexible pavement may be constructed in a number of layer and the top layer has to be the strongest as the highest compressive stresses are to be sustained by this layer, in addition Jo the wear and tear due to the traffic. The lower layers have to take up only lesser magnitudes of stresses and there is no direct wearing action due to traffic loads, therefore inferior materials with lower cost can be used in the lower layers. The lowest layer is the prepared surface consisting of the local soil itself, called the subgrade. A typical cross section of a flexible pavement structure this consists of a wearing surface at the top, below which is the base course followed by the sub-base course and the lowest layer consists of the soil subgrade which has the lowest stability among the four

typical flexible pavement components. Each of the flexible pavement layers above the subgrade, viz. sub-base, base course and the surface course may consist of one or more number of layers of the same or slightly different materials and specifications

The cement concrete pavement slab can very well serve as a wearing surface as well an effective base course. Therefore usually the rigid pavement structure consists of a cement concrete slab, below which a granular base or sub-base-course may be Though the cement concrete slab can also be laid directly over the soil subgrade, this is not preferred particularly when the subgrade, consists of fine grained soil. Providing a good base or sub-base course layer under the cement concrete slab, increases the pavement life considerably and therefore works out more economical in the long run. The rigid pavements are usually designed and the stresses are analyzed using the elastic theory, assuming the pavement as an elastic plate resting overran elastic or a viscous foundation.

3.2.2 Semi-Rigid Pavements

When bonded materials like the pozzolonic concrete (lime-fly ash-aggregate mix), lean cement concrete or soil-cement are used in the base course or sub-base course layer the pavement layer has considerably higher flexural strength than the common flexible pavement layers. However these bonded materials do root possess as much flexural strength as the cement concrete pavements. Therefore when this intermediate class of materials are used in the base or sub-base course layer of the pavements, they are called semi-rigid pavements. This third category of semi-rigid pavements are either designed as flexible pavements with some correction factors to find the thickness requirements based on experience, or by using a new design approach. These semi-rigid pavement materials have low resistance to impact and abrasion and therefore are usually provided with flexible pavement surface course.

3.3 Soil Subgrade And Its Evaluation

The soil subgrade is a layer of natural soil prepared to receive the layers of pavement materials placed over it. The loads of the pavement are ultimately received by the soil subgrade for dispersion to the earth mass. It is essential that at no time, the soil subgrade is overstressed. It means that the pressure transmitted on the top of the subgrade is within the allowable limit, not to cause excessive stress condition or to deform the same beyond the elastic limit. Therefore it is desirable that at least top 50 cm layer of the subgrade soil is well

compacted under controlled conditions of optimum moisture content and maximum dry density. It is necessary to evaluate the strength properties of the soil subgrade. This helps the designer to adopt the suitable values of the strength parameter for design purposes and in case" this supporting layer does not come up to the expectations; the same is treated or stabilized to suit the requirements.

Many tests are known for measuring the strength properties of the subgrades. Mostly the tests are empirical and are useful for their correlation in the design. Some of the tests have been standardized for the use. The common strength tests for the evaluation of soil subgrade are:

3.4.1. California bearing ratio test

3.4.2. California resistance value

3.4.3. test Tri-axial compression test

3.4.4. Plate bearing test.

3.4.1 California Bearing Ratio (CBR) test

This is a penetration test developed by the California Division of Highways, as a method for evaluating the stability of soil subgrade and other flexible pavement materials. The test results have been correlated with flexible pavement thickness requirements for highways and air fields. The CBR test may be conducted in the laboratory on a prepared specimen in a mould or in-situ in the field.

The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame with the cylindrical plunger of 50 mm diameter and dial gauges for measuring the expansion on soaking and the penetration values,

Briefly the penetration test consists of causing a cylindrical plunger of 50 mm diameter to penetrate a pavement component material at 1.25 mm/minute. The load values to cause 2.5 mm and 5.0 mm penetration are recorded. These loads are expressed as percentages of standard load values at respective deformation levels to obtain CBR value. The standard load values obtained from the average of a large number of tests on soil are 131.6 and 173.4 kg respectively at 2.5 and 5.0 mm penetration.

The specimen in the mould is subjected to four days soaking and the swelling and water absorption values are noted. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame as shown in

Fig. 6.13. The load values are noted corresponding to penetration values of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The load penetration graph is plotted as shown in Fig. 6.14. Alternatively the load values may be converted to pressure values and plotted against the penetration values.

Two typical types of curves may be obtained as shown in Fig.3. The normal curve is with convexity upwards as for Specimen no. 1 and the loads corresponding to 2.5 and 5.0 mm penetration values are noted. Sometimes a curve with initial upward concavity is obtained, indicating the necessity of correction as for Specimen no. 2. In this case the corrected origin is established by drawing a tangent AC from the steepest point A on the curve. The load values corresponding to 2.5 and 5.0 mm penetration values from the corrected origin C are noted.

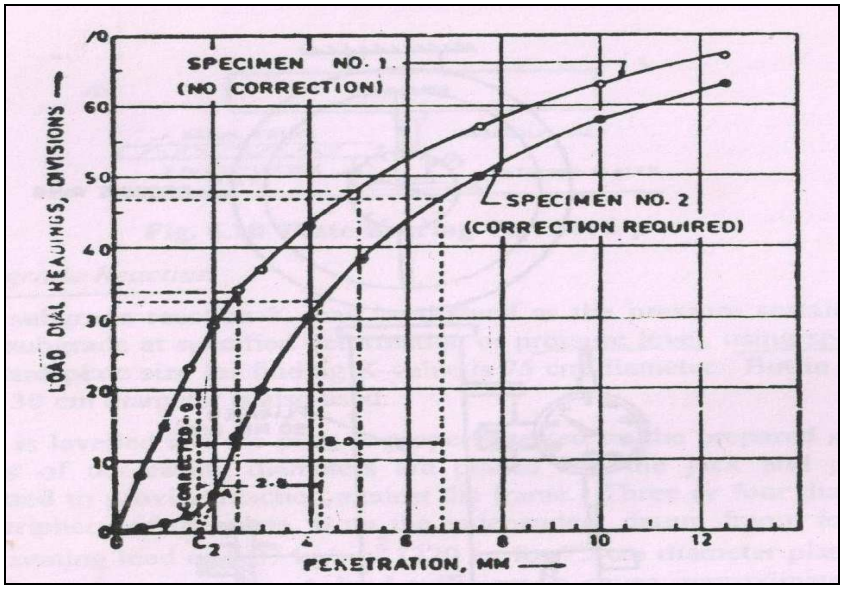

Figure 3 Load-Penetration Curves in C.B.R. Test

The causes for the initial concavity of the load-penetration curve calling for the correction in origin are due to: (i) the bottom surface of the plunger or the top surface of the soil specimen not being truly horizontal, with the result the plunger surface not being in full contact with the top of the specimen initially and (ii) the top layer of the specimen being too soft or irregular.

The C.B.R value is calculated using the relation:

$$\text{CBR \%} = \frac{\text{Load (or pressure) sustained by the - specimen at 2.5 or 5}}{\text{Load (or pressure) sustained by standard aggregates at the corresponding penetration level}} \times 100$$

Normally the CBR value at 2.5 mm penetration which is higher than that at 5.0 mm is reported as the CBR value of the material. However, if the CBR value obtained from the test at 5.0 mm penetration is higher than that at 2.5 mm, then the test is to be repeated for checking. If the check test again gives similar results, the higher value obtained at 5.0 mm penetration is reported as the CBR value. The average CBR value of three test specimens is reported to the first decimal place, as the CBR value of the material. If the variation in CBR value between the three specimens is more than the prescribed limits, tests should be repeated on additional three samples and the average CBR value of six specimens is accepted

Table 2:-CBR Test details

High tension wire road M.S.Palya ward no-03				
Penetration	**Ring Division**	**Load**	**Correction Factor**	**CBR Value**
mm		Kg		
0.00	0	0	-	-
0.50	5	29.9	-	-
1.00	11	65.8	-	-
1.50	14	83.7	-	-
2.00	18	107.6	-	-
2.50	22	131.6	-	-
3.00	24	143.5	-	-
4.00	27	161.5	-	-
5.00	29	173.4	-	-
7.50	31	185.4	-	-
10.00	33	197.3	-	-
12.50	34	203.3	-	-
CBR at 2.5mm		9.6		%
CBR at 5.0mm		8.4		%

9th main road Adithya nagara layout ward no-03				
Penetration	**Ring Division**	**Load**	**Correction Factor**	**CBR Value**
mm		Kg		
0.00	0	0	-	-
0.50	8	47.8	-	-
1.00	10	59.8	-	-
1.50	13	77.7	-	-
2.00	17	101.7	-	-
2.50	19	113.6	-	-
3.00	22	131.6	-	-
4.00	25	149.5	-	-
5.00	28	167.4	-	-
7.50	33	197.3	-	-
10.00	35	209.3	-	-
12.50	37	221.3	-	-
CBR at 2.5mm		8.29		%
CBR at 5.0mm		8.15		%

2nd main road Giridhama nagara ward no-03				
Penetration	**Ring Division**	**Load**	**Correction Factor**	**CBR Value**
mm		Kg		
0.00	0	0	-	-
0.50	7	41.9	-	-
1.00	11	65.8	-	-
1.50	14	83.7	-	-
2.00	18	107.6	-	-
2.50	20	119.6	-	-
3.00	23	137.5	-	-
4.00	26	155.5	-	-
5.00	29	173.4	-	-
7.50	32	191.4	-	-
10.00	36	215.3	-	-
12.50	39	233.2	-	-
CBR at 2.5mm		8.73		%
CBR at 5.0mm		8.44		%

4. MATERIAL AND GEOTECHNICAL INVESTIGATIONS

4.1. Summary and Recommendations

To obtain the Geotechnical and Materials characteristics of project stretch, an extensive study of the existing pavement sub-base, carried out. Accordingly, the stipulated tests have been performed and the summary of test results along with the recommendations has been attached.

- Atterberg limit test were conducted & the results are attached in annexures.
- CBR test for proposed new construction,

4.2. Investigation of Existing Sub-grade and Pavement Composition

4.2.1. Objective

The objective of the investigations is to provide basis for overlay design for existing pavement for the project road, keeping in view the composition and characteristics of the existing pavement/sub grade. The scope of work thus includes:

- Collections of information regarding the existing pavement crust composition and characteristics.
- Existing Sub grade type and sub-soil conditions.

4.2.2. Methodology for Sub-grade Soil and Pavement Crust Investigations

Test pits of approx. 1.0 m x 1.0 m size staggered along the edge of the existing pavement on both sides are excavated up to sub grade level (up to 1.5 m depth) at regular intervals along the road alignment. These test pits are excavated on shoulders extending about 20cms into the pavement.

Bulk sample of about 30 kg was collected from all the test pits at natural ground level to analysis the characteristics of the existing sub grade material. Field density tests were conducted for all the test pits and also the natural moisture content were determined at each test pits.

The following laboratory tests were conducted for all the samples collected from the test pit.

- Grain size Analysis (As per IS: 2720-Part 4).
- Atterberg limits test (As per IS: 2720-Part 5).
- Moisture content test

The existing crust thickness and type of the pavement component layers are measured and recorded on exposed faces of the pavement.

4.2.3. Laboratory Test Results of Soil Samples

The soil samples of the subgrade collected from the test pits are tested in the laboratory and the test results for Grain size classification, Atterberg limits, corresponding OBC values etc. are attached.

5. DESIGN STANDARDS & PAVEMENT INVESIGATIONS

5.1. General

The Primary Data Collected from the site provides a clear picture of the site conditions and also gives us a good insight about the deficiencies and the scope for the improvements. The primary data coupled with the good engineering expertise lead us in giving optimum and economical recommendations for the improvements .A Budget of 10,00,00,000/- (Rs Ten Crores only) has been allocated for this project .Hence the provisions of items made in the cost estimate are in consensus with the allocated budget

The Following are the Improvement Proposals which are discussed below.

5.2 New Flexible Pavement

5.2.1 Bituminous & Concrete Surface

Table 3:-Crust thickness details

Sl. No	Particulars	Crust thickness
1	GSB	150
2	WMM	200
3	DBM	50
4	BC	40

5.2.2 Treating Distress Portion

The Distress portion is cut open and filled with Wet Mix and Compacted and Bituminous Macadam is laid over that the designed overlay components will be given

5.2.3 Treating Crank, rutting and patch work

The portion is scarified after scarification it is cleaned and applied with tack coat and bituminous layer is provided to the required Profile and over that overlay component will be provided.

5.2.4 Other Proposals

The Other proposals include Road marking & construction of Recharge pit etc

5.2.5 Design standard referred

Design standards related to pavement design are essentially based on the guidelines given in IRC - 37- 2001 “Guidelines for design of flexible pavements “and design standards

related to overlay design are essentially based on IRC: 81 - 1997b "Guidelines for strengthening of flexible road pavements using Benkelman beam deflection technique". The suggested design values/ standards and recommended values based on site conditions and data analysis are detailed in Table 2 and are adapted in the design.

Table 4:- Pavement / Overlay Design Standards

SI No.	Design Parameters	Reference Code/Design Values
1.	Pavement Design	IRC:37-2001-"Guidelines for Design of Flexible Pavements"
	• Traffic Growth Rate	Estimated Annual Growth Rate
	• Design Life	Widening (Stage Construction) • 20 Years for sub grade, Base and Sub Base • 10 Years for Bituminous Layers
	• Vehicle Damage Factor	As per the data collected and compiled.
	• Lane Distribution Factor	As per IRC : 37-2001
	• Minimum Thickness	Sub Grade - 500 mm Sub Base - 150/200 mm (<10msa/>10msa) Base - 225/250 mm (<2msa /> 2msa) Bituminous surfacing - Desirably 40 mm thick to prevent ingress of water through surface.
2.	Overlay Design	IRC : 81 - 1997 " Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique "
	• Design Life	10 Years
	• Correction Factors	Temperature correction Factor Correction for seasonal variation (Inclusive of correction for Moisture Content. Soil Type and Rainfall)
	• Minimum Thickness	From Structural Considerations recommended minimum Bituminous Overlay Thickness is 40mm BC (minimum)+50mm DBM or 25mm SDBC+50mm DBM Based on Traffic
3.	Wearing Course Material (Options)	Bituminous Concrete with Crumb Rubber Modified Bitumen / Plastic Waste

5.3 Design Standards Related to Road & Drainage

Drainage of water from Pavement Surface is of paramount importance as far as preserving the road assets created by investing huge funds in addition to maintaining the structural soundness and functional efficiency of the road is concerned. Design Standards related to road drainage are essentially based on the guideline given in IRC: SP: 42 - 1994 "Guidelines on Road Drainage "and in SIRC: SP: 50- 1999 "Guidelines on Urban Drainage ". The suggested Design Values / Standards are detailed in

Table 5:- Design Standards Related to Road Drainage

SL.NO	Design Parameters	Design Values
	• Camber	1.7-2.5% (bi-Directional) for Carriageway (Camber of 3% is Adopted)
	• Longitudinal • Gradient	Minimum 0.3-0.5% For Satisfactory Drainage

5.4 Design Standards Related to Utility, Road Furniture and Appurtenances

Utility and Importance of the Road are gently enhanced by installing Road Furniture and Appurtenances at appropriate location along the Project Road, Which ensures improved Road Safety. Planning and Design of Road furniture and appurtenances are as per the Guidelines Stipulated in IRC. Detailing of each of these components has been done so that to integrate the same with Road Improvement Scheme. The Suggested Design Values/Standards are detailed in Table 5

Table 6:- Design Standards Related to Utility, Road Furniture and Appurtenances

SL.NO	Design Parameters	Reference Code/Design Values
1	Accommodation of Utility Services	IRC:98-1997 "Accommodation of Utility Services on Roads in Urban Area"
2	Road Markings	IRC: 35-2015 "Code of Practice for Road Marking"
3	Road Sings	IRC : 67-2001 "Code of Practice for Road Signs"
4	Road Delineators	IRC:79-2019 "Recommended Practice for Delineators"
5	Pedestrian Facilities	IRC : 103 - 2012 "Guidelines for Pedestrian Facilities "
6	Metal Beam Crash Barriers	At locations where embankment height is more than 3m.

In Addition to the above measures, various other integral Road components have been planned so that to achieve the maximum and optimal use of the carriageway with no/least

interference to traffic flow and at the same time ensuring adequate facilities to other road users especially pedestrians. All the encroachments, if any shall be cleared with the ROW.

5.5 Summary

The design for overlay has been carried as per IRC guidelines for the project stretch and is given below:

Note:

1. **Existing Road surface shall be Overlaid with and M30 Cement Concrete**

5.6 Sub Soil Investigation

Pavement composition details (pavement layers, material type and thickness) were logged on all three sides. Representative samples were collected from sub grade of test pits as well as from a depth of 1.0 m below sub grade. Soil samples were rested in the laboratory for gradation, Atterberg limits. Comprehensive details of test results of the above investigation are attached.

5.7 Pavement Structural Design.

The following guidelines have followed for design of new pavement and for design of overlays for the existing pavements.

- ✓ IRC: 81-1997 Guidelines for Strengthening of Flexible Road Pavement using Benkelman Beam Deflection Technique.
- ✓ IRC: 37-2018 Guidelines for Flexible pavement Design

5.8 Detailed Design

5.8.1. Design Speed

Design speed of 40 kmph has been considered. At some locations design speed reduces less the specified due to ROW constraints.

5.8.2. Carriageway width

Width of the carriageway on the entire stretch varies from 4.00m to 6.50m. It is proposed to strengthen the existing Road Surface and reconstruction of existing earthen road with new pavement crust.

5.8.3. Geometric design

Design standards related to road geometric along with the suggested design values/standards and recommended values based on site condition and data analysis are detailed in Table 6

Table 7:- Geometric Design Standards

Sl No.	**Design Parameters**	**Reference Code**
1	Design	IRC: 69 - 1977-"Space Standards for Roads in Urban Areas". IRC: 86 - 1983-"Geometric Design Standers for Urban Roads in Plains". IRC: 92 - 1985-"Guidelines for the Design of Interchanges in Urban Areas". Design speed Considered is 40 kmph.
2	Geometric Design Standards	
	• Carriageway Width	Two lane-Single Carriage way
	• Footpath at grade level	1.5m-2.0m
	• Camber (Bi – directional)	2.5% for paved carriageway
	• Super Elevation	Limited to 4%
	• Horizontal Curves	IRC: 38 – 1988 –"Guidelines for Design of Horizontal Curves for Highway and Design Tables" (First Revision)
	• Vertical Curves	IRC: SP: 23 – 1993 –"Vertical Curves for Highways".

5.9 Computation of Design Traffic (as per IRC-37, 2012)

Traffic projections available from traffic study have been used for design of pavements. The design traffic is considered in terms of cumulative number of standard axles to be carried during the design life of the road. Its computation involves estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicles damage factor to convert commercial vehicles to standard axles.

The following equation is used to compute the design traffic in terms of the cumulative number of standard axles.

$$Ns = \frac{365 \times [(1+r)^{n}-1]}{r} \times A \times D \times F$$

Where,

Ns = Cumulative number of standard axles to be catered for in the design.

A = Initial Traffic, in terms of commercial vehicles per day modified to account for lane distribution.

r = Annual growth rate of commercial vehicles (Growth rate adopted as per the recommendation Chapter 3).

n = Design life in years (10 years)

F = Vehicle Damage Factor

The design traffic computed in terms of cumulative number of standard axles (msa).

5.10 Road Furniture and Signage

Retro-reflective thermoplastic road markings required cautionary & mandatory signs are planned for the entire length.

6. ROAD SAFETY AUDIT

6.1 Project Brief

Consultant is proposed to be improved with better riding quality and enhanced safety. Road Safety Audit addresses identification of safety related deficiencies as well as behavioral safety issues while subsequently recommending countermeasures in approaching towards sustainable design solution. All sections of the project corridor are visited and studied. Review and audit of safety measures of the corridor are followed with the prevailing best practices. With proposed improvement option of two lanes with paved shoulder and granular shoulders, the objective of the exercise focuses on abating road accidents and their severity while improving riding quality.

6.2 Accidents Statistics

First Information Report (FIR) details relating to the accidents, fatalities and injuries in the project corridor and its immediate influence area are collected and studied. Though such information is recorded by police stations, there is a potential scope of other minor injury and property damage accidents to not have reported. However, efforts are extended in preparing safety improvement options beyond available accident data and the same is incorporated in final improvement proposals

6.3 Safety Issues for Project Corridor

6.3.1 Carriageway

It is observed that carriageway and shoulders are inadequate in width. It is essential to increase the carriageway width in this entire stretch at least up to 10.0 meters + edge strips 0.5 m on either side for improved safety.

6.3.2 Geometric Design

During the audit, it is identified that sight distance at sharp curves lack in standards and needs to be improved with geometric design. Curve passing through villages needs proper signage. Appropriate control measures are essential.

6.3.3. Intersections/Junctions

There are five major junctions observed on the project corridor. It is observed that considerable habitants gather near these junctions; thereby generating local trips. It is audited that the existing junction design lacks in incorporating local travel behavior and influence of habitations in proximity, which makes them potential accident prone spots. It is identified that careful attention needs to be given in developing appropriate designs for these junctions. In addition, provision of suitable location of bus stops near junction needs to be considered.

6.3.4 CD Structures

The cross drainage works, especially culverts/Canals, are narrow in width and the parapets of the culverts are potential hazards.

6.3.5 Traffic Management and Control Issues

It is identified that traffic signs needs to be provided at many places. Existing signage's are in a poor condition. It is identified that provision of pavement markings lack at various places on the project corridor.

Identified Issues And Suggestions

1. Suggestions, recommendation as well as issues identified from safety audit are incorporated into final improvement options which include, but not limited to:

a. Deficient horizontal curves;
b. Identified major/minor intersections (including access roads);
c. Identified highway sections near habitations and;
d. Identified deficient 59 structures.

2. The details of the recommended interventions are presented in Volume III Road Safety Audit.

7. COST ESTIMATES

7.1 Detailed Cost Estimate

Detailed cost estimate Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division. Is fixed 5196.00m New CC Drain, 25 new culverts 4351.00m New BC & 1246.00m New CC Road. length for improvement of roads & drain is included in this road and drain estimate.

7.2 General

Cost Estimate is an important part of the DPR as it provides vital input to financial evaluation of the project. The cost estimates have been prepared for strengthening of the existing road, improvement of existing earthen road, longitudinal drains and road furniture.

7.3 Basic rates

As part of Detailed Project Report, Rate Analysis of each of the item has been prepared by adopting PWD & IWTD SR 2018-19, Bangalore Circle. The rates as given in PWD& IWTD SR are to be enhanced by 6% for additional weight age for the works to be executed under extra ordinary conditions for Bangalore Metropolitan Limits. Items not covered in NHSR / PWD & IWTD SR have been based on market rates.

7.4 Utility Relocation

As the part of the project stretch is earthen road with semi built-up area with all the utilities are placed in the existing earthen road. So Provision for utility relocation is considered in the cost estimated for shifting electric supply lines, telephone lines, OFC lines and other utilities.

7.5 Project Management and Quality Control

Provision of 2.00% of Construction Cost has been made towards Cost of DPR Preparation, PMC and Proof Checking.

7.6 Project Cost

The total project cost for Developmental works in ward No 03 is fixed as 5196.00m New CC Drain, 25 new culverts 4351.00m New BC & 1246.00m New CC Road of Amount is 1000 Lakh. Detailed Cost Estimate is enclosed in **Annexure A.5.1**

8. CONCLUSION

The Project Corridor is located in North- South Part of Bangalore City, which connects Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division. The Project Corridor is located in Residential and Commercial area. Length of the project corridor is 5196.00m New CC Drain, 25 new culverts 4351.00m New BC & 1246.00m New CC Road. The study area caters to considerable local and through traffic commuting between Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division. The spurt in the residential and commercial development around the area resulted in change of the Land Use Pattern. Further, Bruhat Bangalore Mahanagara Palike has decided to take up the development of various Arterial and Sub Arterial roads in and around Bangalore city **"Bangalore Smart city Grants"** Grants where the intensity of traffic has increased significantly and there is a requirement for augmentation of capacity for safe and efficient movement of traffic. This being the Background, Bruhat Bangalore Mahanagara Palike has proposed Restoration and Improvements of roads M.S Palya, Aishwarya Bakery road, Giridhamanagara and surrounding areas in ward no-03 of Yelahanka New town Sub division order to provide Seamless Traffic Flow and to Increase Level of Service along the Project Stretch.

For the proposed Improvement Scheme, total Cost of the Project has been worked out as Rs.1000.00Lakhs.

9. SITE PHOTOGRAPHS

The consultant has captured photographs of important features along the road networks during the field surveys and investigations. The selected photos corresponding to all the field surveys and investigations for the project road are given in this section. The photographs depicts existing road scenarios like the locations where road alignment is existing, buildings or places of worship coming within the proposed ROW, utility lines crossing the proposed ROW, poor condition of the existing roads, railway crossings etc.

9.1 Road Inventory Survey Photos

Images captured for project Road at the time of Road Inventory Survey is presented be

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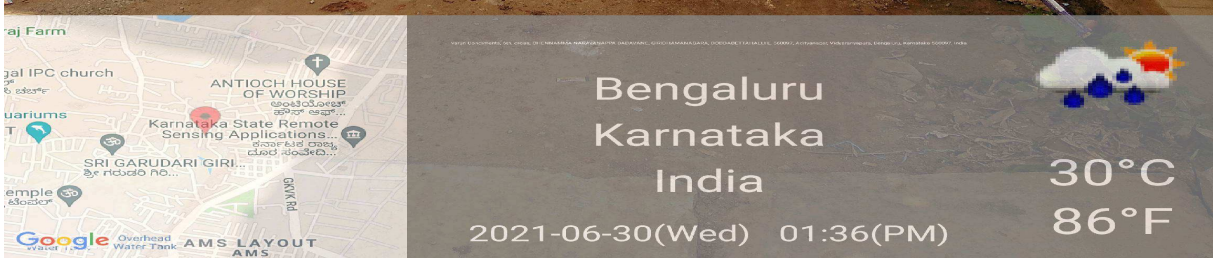
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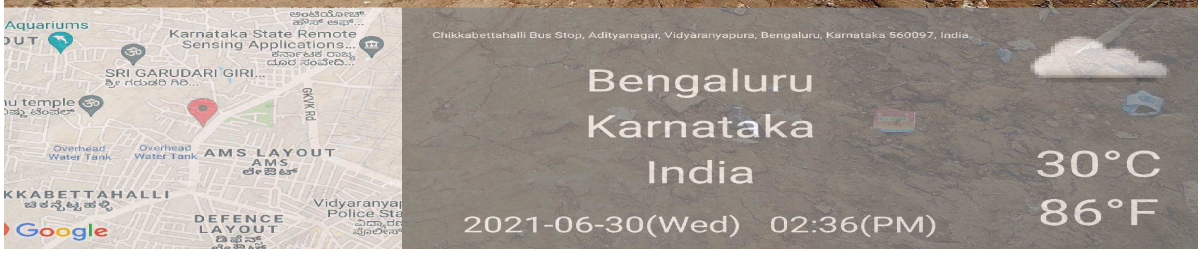
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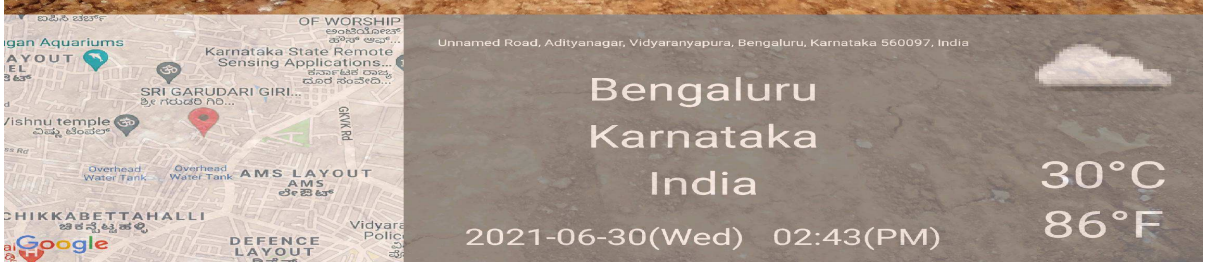
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